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# Data Acquisition System for Electric Vehicle's Driving Motor Test Bench Based on VC++*

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**Abstract**

In order to solve such problems as great labor intensity, high cost, low efficiency and accuracy during the performance experiment for driving motor system of electric vehicles, and realize data acquisition automatically and synchronously, a data acquisition system for driving motor test bench based on visual instruments is designed. This data acquisition system can be used to obtain the driving motor's parameters of currents and voltages at the same time. This system's hardware is based on electric vehicle's motor test bench in Beijing Institute of Technology, and combined with PXI2010 data acquisition card from ADLINK Company. Visual c++ software is adopted as development tool. In this paper, the design and realization of the hardware and software are presented. Experiment results show that this system improves the efficiency and quality of testing task with high utility. And experiment data can be obtained accurately.



*Keywords:* Electric Vehicle; Driving Motor Test Bench; Data Acquisition System; Visual Instruments; VC++ Software.

## I. Introduction

From the beginning of this century, electric vehicle (EV) technology has been accelerated in China[1]. The 2008 Beijing Olympic Games and the 2010 Shanghai World Expo have accelerated the development further[2]. As one of the most important cores of EV, the characteristics of driving motor and its controller system have a significant influence for driving performance of EV. So, more and more test benches for EV driving motor are constructed recently. The experiment data on test bench can determine whether the motor meets the design requirements, evaluate its quality advantages and disadvantages and obtain its further improvement goal and direction, and thus impel the rapid progress of EV technology.

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How to obtain the driving motor's parameters on test bench automatically and synchronously is very important, especially for driving motor's currents and voltages because of the quick change of switch-on-off states of IGBT. The traditional test system by using persons to write down data on paper one by one can't ensure the parameter's record synchronously. It would affect the test quality and accuracy, and lead to error results especially for power or efficiency calculation.

The automatic data acquisition system, which taking computer and modern test technology as its core, is researched and established by authors. Compared with conventional test system, it increases the integration level of the test systems with flexible and compact structure, shortens the development period, and so on[3]. The most important, its automated data acquisition and processing system would ensure the data accuracy, reduce the staff labor time and intensity, and improve test efficiency and capability[4][5].

## 2. Construction of Data Acquisition System

The data acquisition system mainly records the testing information including driving motor, motor's controller, and other equipment. Meanwhile, it can realize the pre-test calibration, data storage and proceeding, analysis, waveform display, and so on.

The data acquisition system is composed by hardware and software. The system construction diagram is shown in Fig.1, where the voltage sensors and current sensors respectively test the DC voltage and current form battery simulator or battery some time, as well as the AC voltage and current between driving motor and its controller. The torque meter measures the torque and speed signals of driving motor. Through the signal conditioning circuit, all the signals are converted to be collected by the PXI2010 acquisition card. Finally the waveform of data can be display in the computer (PC) graphically.

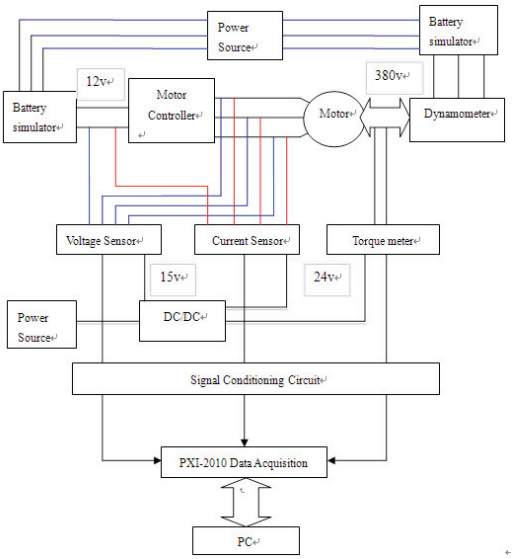


Fig. 1 System construction diagram

## 3. Software Achievement and Methods

Software is important to the data acquisition system. It can synchronously collect and process the characteristic parameters of the motor and controller, meanwhile display the test results. The software of

this system is composed by many modules, such as the login module, the information registration module, the channel calibration module, the data acquisition module, the graphic display module and others. Each module achieves the functions and algorithms through software, thus simplifying the hardware resources. These modules, which can run singly, are designed independently, but related on function realization each other. The basic flow between the modules is shown in Fig.2.

## 4. Key technologies for data Acquisition system

### *4.1 Connection of VC++ with the Database*

A database should be established firstly in order to connect with VC++ software. The entity relationship of the database based on ACCESS is shown in Fig.3.

The common database interfaces in the current Windows Operation system are listed as follows: ODBC (Open Database Connectivity), MFC (Microsoft Foundation Classes), ODBC classes, DAO (Data Access Objects), RDO (Remote Data Objects), OLE DB (Object Linking Embedding Database), ADO (ActiveX Data Objects). Compared with other interface technology, the ADO interface technology has the following advantages: ease to use, supporting any kind of the OLE DB data sever, operating any OLE DB data source, expansibility, etc[6]. Therefore, in this paper, ADO is used for linking the database. The interface is shown in Fig.4.

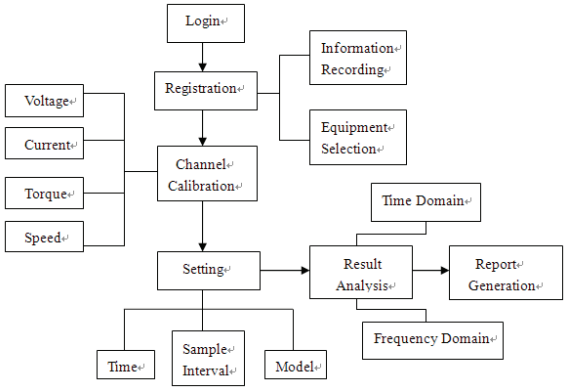


Fig. 2 Software flow diagram

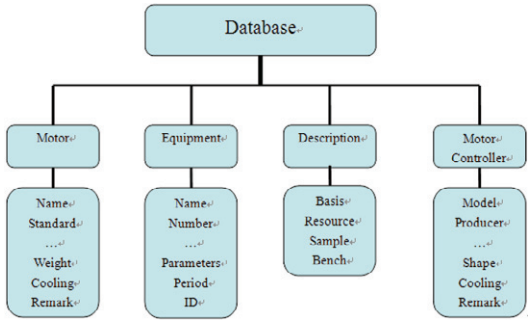


Fig. 3 Entity relationship diagram


Fig.4 Register interface

The corresponding contents of the database are shown in Fig.5.

### *4.2 Calibration Technique*

In order to guarantee the accuracy of the data recording, the data acquisition system should have the function of calibration. There are many calibration methods such as offline steady state, online steady state, automatic optimization, the latest transient state optimization, and so on. The calibration method adopted in this paper is the least-square (LS) method for linear fitting with limited number of points. The calibration interface of the system is shown in Fig.6.

During calibration, the parameters of driving motor can be monitored quantitatively on computer by comparing with other more precise instruments. Through the calculation procedures in VC++ software program, the calibration can be finished.

For least-square method, $y = k \times x + b$ is chosen as the linear regression equation. The key is to find the optimal $k$ and $b$ based on the measured data. It is assumed that the deviation $d$ between $y$ and $k \times x + b$ in the same point $x$ can be calculated as follow.

总体描述 ： 表

| 测试依据 | 任务来源目的 | 采样方式 | 测试台架 | 检测日期 |
|---|---|---|---|---|
| GB/T18488.1 | 北京 测试 | 送样 | 北京理工大学车用 | 2010.8.31 |

电机标称 ： 表

| 电机名称 | 执行标准 | 制造厂商 | 生产日期 | 额定功率 | 额定电压 | 额定转 |
|---|---|---|---|---|---|---|
| **电机 | GB/T18488.1 | 北京理工大学 | 2010.5.1 | 50kw | 220V | 2500r/min |

电机控制器标准 ： 表

| 型号 | 研制单位 | 输入电压 | 控制电源 | 原厂编号 | 生产日期 | 出厂日期 |
|---|---|---|---|---|---|---|
| dsk500 | 北京理工大学 | 380V | 380V | 73754 | 2010.7.1 | 2010.9.10 |

Fig. 5 Corresponding contents of the database


Fig. 6 Calibration interface

$$d_1 = y_1 - b - k \times x_1 \tag{1}$$

$$\cdots$$

$$d_n = y_n - b - k \times x_n \tag{2}$$

Set:

$$D = \sum d_i^2 = \sum_1^n [y_i - b - k \times x_i]^2 \tag{3}$$

By setting the second partial derivative of $D$ bigger than zero, and the first partial derivative of $D$ equal to zero, $k$ and $b$ can be gotten. This LS method can also be simplified to be linear calibration by only using two points to calibration as follow.

$$k = \frac{y_2 - y_1}{x_2 - x_1} \tag{4}$$

$$b = y_1 - k \times x_1 \tag{5}$$

This: $x_1$ is measure value of first piont; $x_2$ is measure value of second point; $y_1$ is calibration value of first piont; $y_2$ is calibration value of second piont.

*4.3 Data Acquisition and Waveform Display*

In order to guarantee the driving motor's signals of voltage and current can be obtained quickly and synchronously, the Direct Memory Address (DMA) technology is used in this data acquisition system. During DMA working mode, the bus is managed directly by DMA controller. So, the system also sets a process about the transfer of the bus control between DMA controller and CPU[7]. Before DMA mode working, CPU hands over the control of the bus to DMA controller, and after the transfer, the DMA controller returns the control of the bus to CPU.

The DGraph control unit provided by the data acquisition card producer is used to show waveform display. But this control unit can only display the experimental data in static state. In order to display the figures dynamically, the DGraph control unit and the OnTimer are worked together in the software program of VC++.

## 5. Experiment

An induction motor that is used in EV is tested on test bench. And the data acquisition system which is designed in this paper is applied.

After calibration, two Hall voltage sensors are used to measure the DC voltage form battery simulator and the AC voltage between driving motor and its controller. At the same time, two current sensors are also used to test the current form battery simulator and the current between driving motor and its controller. When the motor is tested, the signal's information of the driving motor system is transferred to computer after through conditioning circuit and other hardware system, and processed by data acquisition software.

When the motor is tested at 500r/min, and the load torque is 347.8Nm, the parameters of DC current and DC voltage from battery simulator, and the AC current and AC voltage from motor controller are obtained by using the designed data acquisition system. Fig.7 shows these dynamic waveforms.

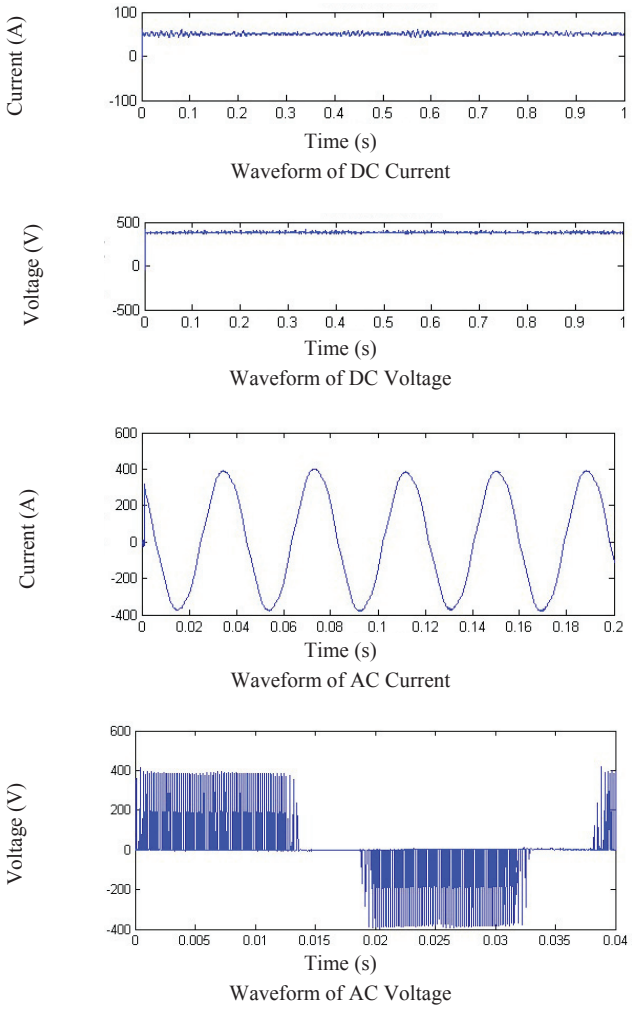


Fig.7 Dynamic waveforms of currents and voltages

## 6. Conclusion

In this paper, a data acquisition system is designed, and its construction of software and hardware is demonstrated briefly. Some key technologies are explained. By using ADO interface technology, the database is established. It can register the information of the tested motor, and inquire the experimental records. The least-square method is utilized to calibrate the system. And dynamic waveform display is realized by programming DGraph control unit and the OnTimer working together. Experiment results show its utility. This system will reduce the staff labor time and intensity, and improve test efficiency and capability.

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